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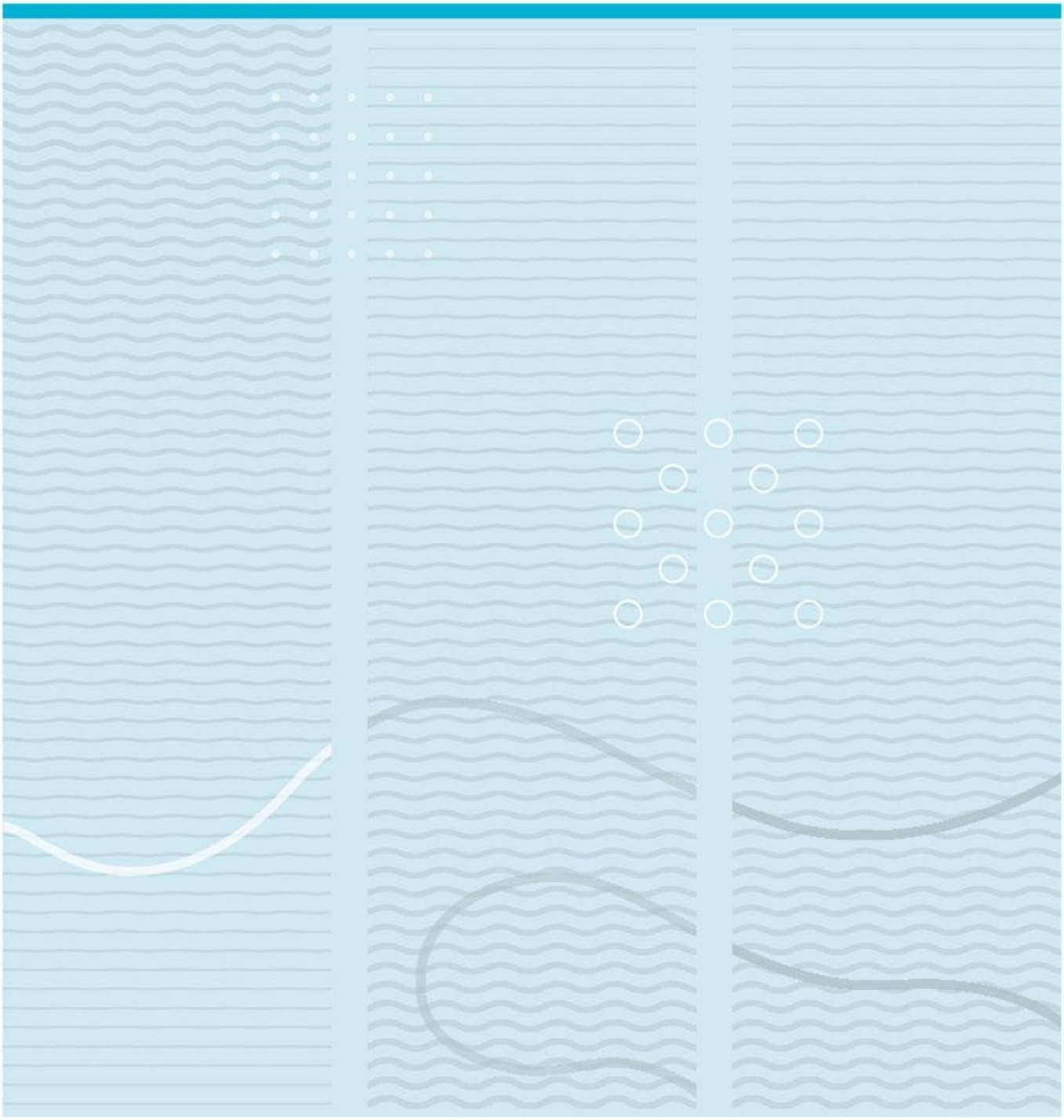
What is the reported association between visual impairment and sleep in adults?



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This thesis is worth 30 study points

Summary

Objective: To evaluate the widespread variations of lack of sleep at humans with visual challenges different methods were used. Many research and experiments has been carried out in harmony with that. The aim of this scoping review is to give an insight of results from this field.

Introduction: The association between sleep inefficiency and visual dysfunction is well known and reported as early as 1956 (Migeon, 1956, as cited in Leger et al., 2002, p. 1607). Melatonin is recognised as the indicator for sleepiness and many research focus on that.

Inclusion criteria: The age of the focus group was between 18 and 60 years (adults). Gender restrictions were not deployed. Articles about all types of eye diseases were included in this review. In order to ensure the encompassing value of the scoping review, both qualitative and quantitative study designs were represented.

Methods: Three reviewers worked on this project. The keywords “visual impairment” and “sleep” were selected for the search which was carried out. PubMed and EBSCO provided 323 articles. After removing dublicates in EndNote the records were transferred to the Rayyan system which was used by the reviewers to screen titles and abstracts. (Ouzzani et al., 2016, p. 210) The criteria were: adult and sleep. Case studies, clinical trials, medical interventions, dream related articles and participants only under age 18 were excluded. The included articles are from year 1992 until 2018. (Klein, 2021, p. 1)

Results: 14 articles remained to be analysed including the selected keywords. In order to analyse the sleep-wake patterns questionnaires were utilised in many cases. In some cases a more complex analysis of melatonin level was measured. Some researchers collected data and analysed them. Other resarchers made a comparison between sighted and visually impaired people. A popular method for the measurements was the PSQI (used 13 times) and the ActiGraph or a combination of these. In one case light shed on the unstable reliability of a subjective method used by many for data collection. To collected data for melatonin assessment samples were taken either from saliva, urine or blood. Different approaches were observed as some professionals evaluated the effect of light entering into the body some others measured the chemicals triggered and produced by light. There was one research that used blood samples to analyse melatonin and cortisol. In two cases, the researchers used saliva to establish melatonin and cortisol

levels. Out of 14 articles described 4 the effects on sleep quality of aMT6s - the urinary metabolite of melatonin.

Conclusions: Based on the figures from those findings conclusions made between the relationship of abnormal melatonin rhythms and changes in circadian phase. Many of them pointed out the presence of abnormal sleep patterns at the absence of light at blind individuals. As a result, blind people suffer from unwanted daytime napping or sleepiness.

Keywords: sleep, visual impairment, blind, light perception, melatonin, cortisol, circadian rhythm, free running, actigraphy, polysomnography, Pittsburgh Sleep Quality Index, urine, saliva.

Sammendrag

Formål: For å evaluere de utbredte variasjonene av søvnmangel hos mennesker med visuelle utfordringer, har forskjellige metoder blitt brukt. Mye forskning og eksperimenter er utført i samsvar med dette. Målet med denne sammenfatning (scoping review) er å gi et innblikk i forskningsresultatene fra dette feltet.

Innledning: Sammenhengen mellom søvnineffektivitet og visuell dysfunksjon er velkjent og rapportert allerede i 1956 (Migeon, 1956, as cited in Leger et al., 2002, s. 1607). Melatonin er anerkjent som indikator for søvnproblemer og mye forskning knytter seg til det.

Inklusjonskriterier: Vi bestemte oss for å fokusere på voksne personer mellom 18 til 60 år. Kjønnsbegrensninger ble ikke brukt. Artikler om alle typer øyesykdommer ble inkludert i denne gjennomgangen. For å sikre bredden i sammenfatningen, ble både kvalitative og kvantitative studiedesign inkludert.

Metoder: Tre lesere jobbet med dette prosjektet. Nøkkelordene "visual impairment" og "sleep" ble valgt for søket som ble utført. PubMed og EBSCO ga 323 artikler. Etter å ha fjernet duplikater i EndNote ble resultatene overført til Rayyan-systemet som ble brukt av lesere til å velge fra titler og sammendrag. Kriteriene var: Voksen og søvn. Casestudier, kliniske studier, medisinske inngrep, drømmerelaterte artikler og deltakere bare under 18 år ble ekskludert. De inkluderte artiklene er fra år 1992 til 2018.

Resultater: Det gjensto å analysere 14 artikler med de valgte nøkkelordene. For å analysere søvnmønstret ble spørreskjemaer brukt i mange tilfeller. I noen tilfeller ble en mer kompleks analyse av melatoninnivået målt. Noen forskere samlet inn data og analyserte disse. Andre forskere foretok en sammenligning mellom seende og synshemmede mennesker. En populær metode for målingene var PSQI (brukt 13 ganger) og ActiGraph eller en kombinasjon av disse. Ett tilfelle kastet lys over liten pålitelighet ved en subjektiv metode som brukes av mange til datainnsamling. For å samle inn data for vurdering av melatonin ble prøver tatt fra spytt, urin eller blod. Ulike tilnærminger ble observert da noen forskere vurderte effekten av lys som kommer inn i kroppen, andre målte kjemikaliene som ble utløst og produsert av lys. Det var et forskningsprosjekt som brukte blodprøver for å analysere melatonin og kortisol. I to tilfeller brukte forskerne spytt for å undersøke melatonin og kortisolnivåer. Av 14 artikler beskrev 4 effekten på søvnekvaliteten av aMT6s - urinmetabolitten av melatonin.

Konklusjoner: Basert på tallene fra disse resultatene ble det trukket konklusjoner om forholdet mellom unormale melatoninrytmer og endringer i døgnfasen. Mange forskere påpekte tilstedeværelsen av unormale søvnmønstre hos blinde personer på grunn av fravær av lys. Som et resultat lider mange blinde mennesker av uønsket «napping» eller søvnighet på dagtid.
Nøkkelord: søvn, synshemming, blind, lysoppfatning, melatonin, kortisol, døgnrytme, friløp, aktigrafi, polysomnografi, Pittsburgh Sleep Quality Index, urin, spytt.

Abbreviations

AE

abnormally entrained aMT6s rhythm

AMD

age-related macular degeneration

aMT6s

6-sulfatoxymelatonin

ASPS

advanced sleep phase syndrome

BDI

Beck Depression Index

BGHA

Brief General Health Assessment

DSPS

delayed sleep phase syndrome

ESS

Epworth Sleepiness Scale

FR

free running aMT6s rhythm

GDBA

Guide Dogs for the Blind Association

HADS

Hospital Anxiety and Depression Scale

LP

light perception

MO

melatonin onset

NE

normally entrained aMT6s rhythm

NLP

no light perception

NREM

non rapid eye movement sleep

PSG

polysomnography

PSQI

Pittsburgh Sleep Quality Index

REM

rapid eye movement sleep

RP

retinitis pigmentosa

SD

standard deviation

SDD

Stargardt's disease

SPSS

The Statistical Package for the Social Sciences

UN

unclassified aMT6s rhythm

Contents

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1 Introduction

Sleep is an essential part of life. The quality of sleep in one's life has an effect on the other areas of life and everyday activities. For example the concentration required at work or school, the frequency and length of daytime napping, the ability to focus and many more activities and performances are influenced by the sleep quality. The majority of the people within the society might not be aware of the problems that visually impaired people face on a daily basis. One of the issues is poor sleep quality in visually impaired people. This problem is particularly prominent in the case of those without light perception. As specialists, Lockley, Arendt and Skene from the polysomnography field phrased it: "These circadian rhythm sleep disorders are chronic, unrelenting, and currently difficult to manage with conventional approaches." (Lockley et al., 2007, p. 311) Upon the first glance, potential sleep disorder "side effect" of being blind is a less obvious and noticeable. The proportion of sleep irregularities among visually impaired people are more frequent than among sighted people as Tamura and his colleagues also observed in their work: "In this study, the rate of individuals reporting irregular sleep – wake pattern, difficulty maintaining sleep and daytime sleepiness were significantly higher in visually impaired participants than in control subjects." (Tamura et al., 2016, p. 1664) This phenomenon recognised by researchers and scholars since 1956 (Migeon, 1956, as cited in Leger et al., 2002, s. 1607). As a result, there has been continuous efforts to improve the situation and quality of life for the people with sight loss. (Leger et al., 1999, p. 193) The different types of sleep deprivation are among the variety of topics being researched on within this field. Sleep deprivation occurs in different forms and in different length. As the eye diseases are also variant from one individual to another, the side effect of sleep disturbance varies in different cases. One of these existing sleep conditions that was scrutinized is known as ''non-24 h sleep/wake disorder''(Skene & Arendt, 2007, p. 651).

This scoping review is conducted in order to gain an overview of what has been done in this field in connection to visually impaired people and sleep quality. Scoping review is a relatively new method as it has been around just over 10 years approximately (JBI GLOBAL WIKI, 2020). The aim of a scoping review is to give an overview of the literature already existing in the field. By summarising findings and drawing conclusions via these works, one can offer a more consistent overview of the topic in question.

This scoping review aims to collect the ideas, facts and results already known about the connection between visual impairment and sleep. For this purpose 14 articles were selected. By looking at these 14 articles one can learn the trends from this field. In this way, the review enables other scholars to determine which future potential research areas to focus on and raise awareness about this problem.

Following is the content of each section in this project, which is structured accordingly to the scope review approach. The text in this thesis is based on the 14 articles that are in focus of the scoping review. The detailed references on the articles can be found in the reference list.

Methods section goes into details regarding the implementation of scoping review approach on this project. This section essentially clarifies the procedure of mapping the information. This begins by stating the primary sources of information, the keywords that were used in the search for materials, and the criteria that were used to further filtering them. This is followed by the general details of the articles that were selected to be analysed in this project, as well as categorising them according to the methods used in these research. This section is then followed by result part, which is interrelated with each other.

Result section summarises the outcome of each research that were selected. The results were then categorised into different groups base on the method used. This was done in the combined form of table and description. For example, what kind of results were produced after the measurement of melatonin in blood, urine and saliva samples; and what were the outcomes generated after the utilisation of PSQI questionnaires. The results are then scrutinised in dept in the next part, discussion section.

Discussion section offers the overview of all the results mentioned in the previous part, along with placing them in the context of the existing current literature in this area.

Lastly, conclusion section provides the overall conclusions of the outcomes, whilst connecting and reinforcing the research question. Additionally, observation and comment on the materials were made, along with suggestions on what could be done to further contribute to this area.

Since there is a number of specific terms that were referred to in the materials used in this scoping review that the readers may not be familiar with, below are the list of terms frequently mentioned in the articles.

Circadian rhythm: "Circadian rhythms are 24-hour cycles that are part of the body's internal clock, running in the background to carry out essential functions and processes. One of the most important and well-known circadian rhythms is the sleep-wake cycle." (Suni, 2020) Can be categorised as: normally entrained (NE), free running (FR), abnormally entrained (AE). (Lockley et al., 1997, p. 3763)

Cortisol: is also known as stress hormone in this case we can name it as activity hormone. In order to sleep less cortisol is needed in the body and more melatonin required for the sleep. That is the reason why cortisol has a higher concentration in the blood in the morning after weaking up to start the body and get ready for the daily activities. (Aubin et al., 2017, p. 515)

Melatonin: is a hormone naturally present and produced in the body, which triggers sleep in the system. (Aubin et al., 2016, p. 104)

Pineal gland: is located inside the brain and responsible to produce and send melatonin in the body to create the sleep rhythm. Also renown as the internal clock of the body. (Villines, 2017)

Sleep index terms: subjective sleep quality, sleep latency, sleep duration, sleep efficiency, sleep disorders, use of sleep medication, and daytime dysfunction are the parts of the Pittsburgh Sleep Quality Index (PSQI) that are evaluated during this survey. Buysse and his colleagues produced this PSQI questionnaire in 1989 and it is still widely used today to assess sleep. (Buysse, 1989, as cited in Barbosa et al., 2017, p. 898) One can look the details of the PSQI questionnaire through the following link: http://www.goodmedicine.org.uk/files/assessment,%20pittsburgh%20psqi.pdf (Hawkins, 2018).

2 Methods

The span of approximately one year in which this research, preparation and evaluation were conducted granted me the time to familiarise with the topic and the method utilised in this project. The details of the alterations of a priori protocol which occurred during this time period are clarified in the following paragraphs.

Initially Helsebibliotek and PubMed were to be the primary sources of the materials used in this research (Klein, 2019, p. 2). However, during the course of the project, I realised the depth in which the data from EBSCO could yield to my research and hence it is later on included as part of the key sources.

Whereas a systematic literature review was originally stated in the a priori protocol, it occurred to me during the preparation phase that scoping review is more suitable and effective for this research. (Klein, 2019, p. 6) Thus, I eventually settled with the scoping review with a qualitative design instead. Although both types of reviews fall within the PRISMA structure system, scoping review can not only act as a stepping stone for future research opportunities, but also can help explore evidence mapping and fill in the knowledge gaps. (University of South Australia, 2021) Since I am not a specialist in sleep disorder, scope review granted me the opportunity to maximise the amplitude of the knowledge I gained through research, even without prior professional in-depth knowledge from the field.

In this project, The Joanna Briggs Institute's (JBI) Manual For Evidence Synthesis is employed along with Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) Checklist (The Joanna Briggs Institute, 2020). These functioned as a guideline to ascertain that all the essential items are included in the scoping review.

Search strategy

With the **"What is the reported association between visual impairment and sleep in adults?"** research question in mind, we limited the search to the keywords: "visual impairment" and "sleep". The most recent search was generated on the 2nd of February 2021. These provided many relevant articles for our topic. Previously tested we found several variations with miscellaneous results. For example, when search with the word "blind", the results included articles where blind tests were used. PubMed provided

112 articles for the search with these keywords. However due to some technicalities, merely around 108 results were shown on PubMed through EndNote. From EBSCO, 215 articles were transferred into EndNote, whilst 10 were in fact duplicates. Additionally, 313 articles entered into the Ryyan system, in which 10 were duplicates. Therefore leaving barely 303 articles for us to analyse. The Ryyan system was utilised in the process of selecting relevant articles by scanning through the titles and the abstract parts of the articles. The preferred language during the selection of the articles was set as English as it is a common language used by all group members, not to mention at most of the published materials were written in English (Klein, 2020, p. 2). The time frame and geographical area was not limited during this selection, which allowed us to have a wider view on the topic. Grey literature was not examined during this review due to access limitation.

In order for the three reviewers who contributed to this project to work at the same pace, virtual preparational meetings were arranged. The main concerns regarding preparation plan was how to revise 303 articles and place them into 3 categories as followings: “include” which are essential material, “maybe” which are potentially beneficial material and lastly “exclude” which are materials that do not fit the scope of the research. Each of the reviewers scanned through the titles and abstracts and marked the articles according to the above mentioned categories in the Ryyan system. A certain criteria used in categorising these materials were agreed upon during the first meeting. For instance, the initial browsing keywords were “adult” and “sleep”. However, articles on case studies, clinical trials, medical interventions, dream pattern and any studies which were conducted on participants under the age of 18 were excluded.

During the second preparation we examined the articles that appeared in the conflicted section of the Ryyan system. At the end of the meeting, we reached an agreement that 24 out of 303 articles would be further analysed.

The third preparational meeting took place after 23 out of the 24 selected articles were gathered, processed and analysed. Note that due to the fact that none of the reviewers found access to the full article of one of the selected materials, we ended up utilising only 23. During this session, the number of participants who participated as research subjects were marked in every article. We also scrutinised the methods employed, the eye diseases mentioned and the sleep analysing methods practised in each article.

On the forth meeting, we decided to narrow down the scope of the materials used in the project to 14 articles to better suit the review. Additionally to the previous marked aspects the study design, the hypothesis and results part of the articles were analysed.

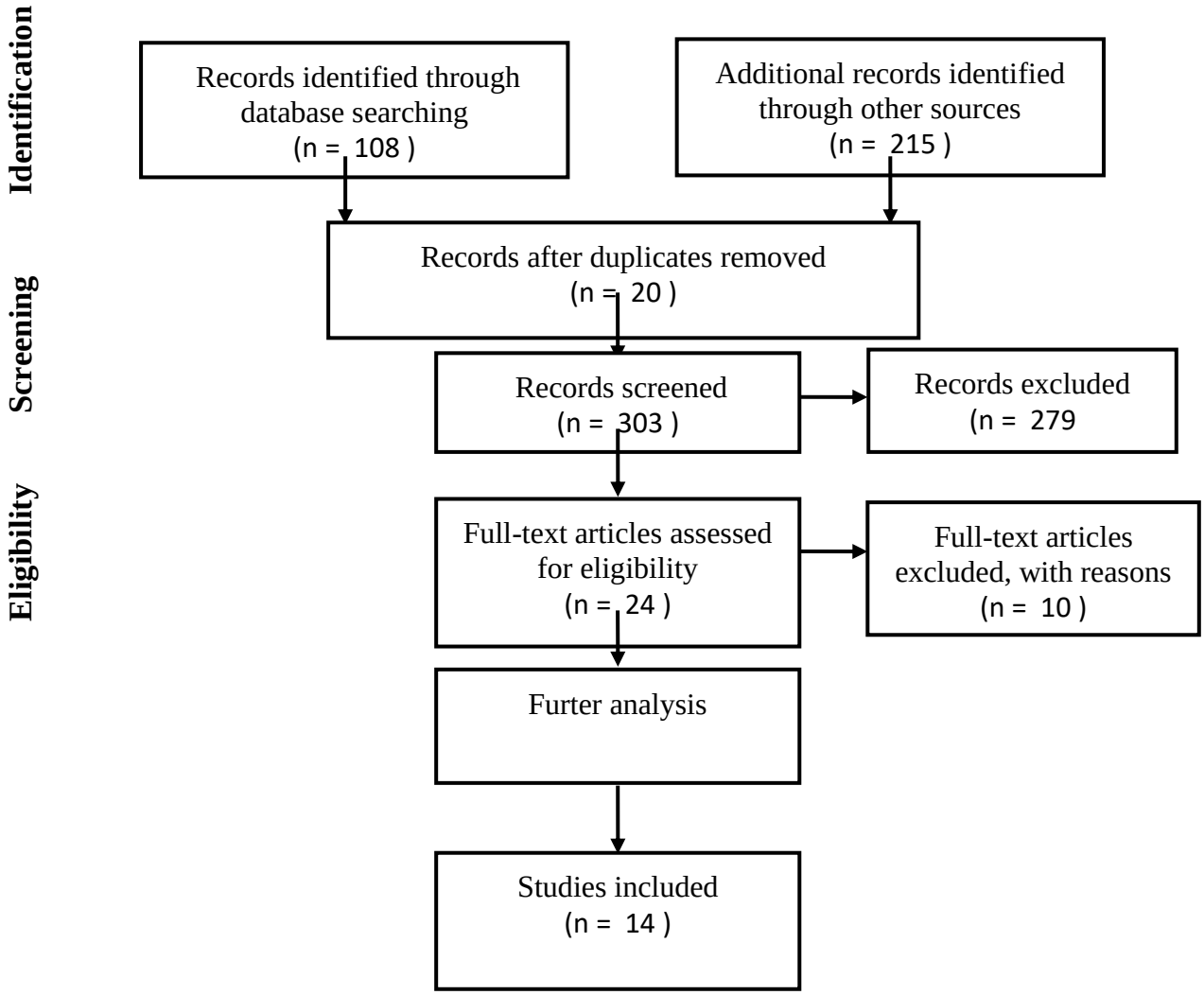
PRISMA Scoping Review Flow Diagram

Title: What is the reported association between visual impairment and sleep in adults? – a scoping review

Keyword 1: visual impairment

Keyword 2: sleep

PubMed, EBSCO


Identification
Screening
Eligibility
Records identified through database searching (n = 108)
Additional records identified through other sources (n = 215)
Records after duplicates removed (n = 20)
Records screened (n = 303)
Records excluded (n = 279
Full-text articles assessed for eligibility (n = 24)
Full-text articles excluded, with reasons (n = 10)
Furter analysis
Studies included (n = 14)

Source of evidence screening and selection

In cases of disagreement during the screening and selection, reviewers referred to the research question and compared the article in question with the inclusion and exclusion criteria.

Data extraction

In order to make a summary and comparison of the selected scoping review items, several aspects were considers. Detection of the following aspects were made:

number of participating subjects in the research
eye condition of the subjects stated in the research
used methods for sight and eye evaluation of the subjects
used methods for sleep evaluation of the subjects
length of the research period
study design of the research
objectives of the research
hypothesis mentioned in the research
geographical location of the research
year of the publication of the research
keywords preferred by the researchers
results of the research
conclusion of the research

The details of each articles are described below, presented in and alphabetical order according to the author of the article. Note that the results and conclusions are shown in separate sections.

Data extraction concerning article number 1 (A1).

Title

Disorders of the Sleep-Wake Cycle in Blindness

Author/year

Aedoti C., Akang, E. E. 2010

Objective/s

The aim is to examine the presence of the different types of sleeping disorders and its effect on the blind, along with the possible connection between the level of visual imparity and sleep disorders.

Participants (characteristics/total number)

170 blind patients participated in this research. Out of 170 patients, 46 had no light perception (NLP), 124 had light perception (LP) or even better vision.

From the participants 89 had cataract, 56 had glaucoma, 10 had optic atrophy (non-glaucomatous), 2 had uveitis and 13 had other type of reason for being blind.

The proportion of male: female ratio was 1.2:1, formed out if 93 males and 77 female participants.

Different age groups were represented in this study, the mean age was 60.4 ± 18.6 years.

Concept

This was a questionnaire based qualitative quantitative study. The Montgomery Asberg Depression Rating scale (MADRS) and the Pittsburg Sleep Quality Index (PSQI) were used during this study. In addition to these another questionnaire was prepared. This had the main focus on the condition of the eye and sleep difficulties in the subjects.

In this study they regarded blind the patients whom had worse than 3/60 visual acuities in the better eye. These patients were divided into 2 subcategories: one with no light perception the other is having light perception. For the evaluation of light perception a pen torch was utilised. This evaluation was part of a complete ophthalmological examination. It was hypnotised that worse vision results in worse sleep efficiency.

Context

Length of the research

As the PSQI is pertaining a 30 days period that is why it's determined as a one month length research.

Geographical location of the research

The research had been carried out in Nigeria, Africa.

Location of the research

The research had been carried out in a Teaching hospital.

Keywords used in the article

"Circadian rhythm, sleep-wake cycle, disorders, blindness, melatonin." (Adeoti & Akang, 2010, p. 163)

Data extraction concerning article number 2 (A2).

Title

Altered sleep–wake patterns in blindness: a combined actigraphy and psychometric study

Author/year

Aubin S., Gacon C., Jennum P., Ptito M., Kupers R. 2016

Objective/s

In this study a comparison made to analyse the rhythm of the circadian circle between sighted and blind people.

Participants (characteristics/total number)

11 diagnosed blind person with no light perception and 11 sighted person participated in this research, as a total of 22 people. The blind group consisted of 8 females and 3 males, having the mean age of 44.5 ± 14.9. The mean age of the sighted group was: 43.4 ± 14.2, here 4 females and 7 males participated.

In each 11 cases vision loss was due to peripheral origin commenced in the retina or in the optic tract.

Concept

To exclude possible neurological disorders among participants Beck Depression Index and the Hospital Anxiety and Depression Scale was performed. Also for the screening part potential participants answered a structure medical interview and REM-Sleep Behavior Disorder (RBD) screening questionnaire. The Epworth Sleepiness Scale (ESS) measured at the same time. In addition to those they stayed sustained observation for one night concerning severe sleep apnea and excessive limb movements. These two elements are undesired during the current research and therefore it was necessary to exclude any possibility of those occurrences.

In this qualitative quantitative case control study parallel to actigraphy recordings PSQI and Morningness-Eveningness Questionnaire was used. All of these collected 30 days length of data. Several aspects of this data were considered including sleep onset and offset, napping throughout the day and sleep efficiency.

For the statistical analysis of the collected data Welch's unequal variance t-tests, multivariate analysis of variance and Pearson's correlations were conducted.

Context

Geographical location of the research

The research had been carried out in Denmark.

Location of the research

2 days spent at hospital and 28 days at home in natural environment and regular rhythm

of life.

Keywords used in the article

“Blindness, actigraphy, circadian rhythms, sleep efficiency, sleep disturbances, light perception” (Aubin et al., 2016, p. 104)

Data extraction concerning article number 3 (A3).

Title

Sleep structure in blindness is influenced by circadian desynchrony

Author/year

Aubin S., Jennum P., Nielsen T., Kupers R., Ptito M. 2018

Objective/s

The main focus here was to examine how altered circadian rhythm phase effect non rapid eye movement sleep (NREM) and rapid eye movement sleep (REM) in the case of individuals with no vision.

Participants (characteristics/total number)

11 diagnosed blind person with no light perception and 11 sighted person participated in this research, as a total of 22 people. The blind group consisted of 8 females and 3 males, having the mean age of 44.5 ± 14.9. The mean age of the sighted group was: 43.4 ± 14.2, here 4 males and 7 females participated.

In each 11 cases vision loss was due to peripheral origin commenced in the retina or in the optic tract.

(*Remarks by the author*. Below I compared the author, publishing and participants details of the two articles above:

Article number 2: Received 5 March 2016, Received in revised form 17 July 2016, Accepted 18 July 2016, Available online 31 August 2016.

Authors: Aubin S., Gacon C., Jennum P., Ptito M., Kupers R.

Participants: The blind group consisted of 8 females and 3 males, having the mean age of 44.5 ± 14.9. The mean age of the sighted group was: 43.4 ± 14.2, here **4 females** and 7 males participated.

Article number 3: Accepted in revised form 22 March 2017; received 15 October 2016. Actually published in 2018.

Authors: Aubin S., Jennum P., Nielsen T., Kupers R., Ptito M. 2018

Participants: The blind group consisted of 8 females and 3 males, having the mean age of 44.5 ± 14.9. The mean age of the sighted group was: 43.4 ± 14.2, here **4 males** and 7 females participated.

The articles written almost authentically by the same authors, so my hypothesis is that the experiment was done at the same time -maybe in year 2016- observing several aspects from this field. Results analysed and articles created out if it later at different points in time. My suggestion is that in both cases the subjects are the same.)

Concept

To exclude possible neurological disorders among participants Beck Depression Index and the Hospital Anxiety and Depression Scale was performed. Also for the screening part potential participants answered a structure medical interview and RBD screening questionnaire. The ESS measured at the same time. In addition to those they stayed sustained observation for one night concerning severe sleep apnea and excessive limb movements. These two elements are undesired during the current research and therefore it was necessary to exclude any possibility of those occurrences.

In this qualitative quantitative case control study one day data collected from nocturnal Polysomnography (PSG) recordings were analysed. With the help of this sleep efficiency, sleep duration and sleep phases were understood better. To process the data DOMINO Analysis Software was utilised. PSQI scores of the participants are also provided in this article.

On a different day for 24 hours saliva samples collected in every 2 hours to follow the circadian phase of the subjects. From the saliva the melatonin concentration value indicates the rhythm of the circadian circle.

For the statistical analysis of the collected data Student's t-tests, one-way analysis of variance, Bonferroni pairwise comparisons, Pearson correlations were conducted using the Statistical Package for the Social Sciences (SPSS) v20 statistical software package.

Context

Geographical location of the research

The research had been carried out in Denmark.

Location of the research

Hospital environment

Keywords used in the article

"Circadian phase, melatonin, REM sleep, NREM sleep" (Aubin et al., 2018, p. 120)

Data extraction concerning article number 4 (A4).

Title

Melatonin and cortisol profiles in the absence of light perception

Author/year

Aubin S., Kupers R., Ptito M., Jennum P. 2017

(*Remark by the author:* according to my estimation, this article takes another aspect of the same research that is numbered as article 2 and 3 here.)

Objective/s

In order to find out more about the reasons behind the reported sleep problems of blind people 2 main indicators of sleep elements -melatonin and cortisol- were investigated.

Participants (characteristics/total number)

11 diagnosed blind person with no light perception and 11 sighted person participated in this research, as a total of 22 people. The blind group consisted of 3 males and 8 females and, having the mean age of 44.5 ± 14.9. The mean age of the sighted group was: 43.4 ± 14.2, here 7 females and 4 males participated.

In each 11 cases vision loss was due to peripheral origin commenced in the retina or in the optic tract.

Concept

Prior to this research several screening steps were done. To evaluate the mental health aspect of the participants, BDI and the HADS questionnaires was utilised. Two structured medical interviews were utilised such us: RBD, ESS. During a one night monitoring procedure the participants were screened for severe sleep apnea.

In this qualitative quantitative case control study saliva was collected for one day by using the Italian Salivette system in every second hours. This enabled the researchers to extract information concerning melatonin concentrations and cortisol. Comparison of these profiles made with the control group in addition to the area under the curve (AUC) aspect. This was done to analyse the synchronicity between the concentration level of the melatonin in the saliva and the night and day rhythm of the environment the subject is found. Concerning cortisol a complete analysis done including the cortisol awakening response (CAR) – that indicated the highest concentration of it after sleep. Additionally the PSQI was also accomplished.

Context

Geographical location of the research

The research had been carried out in Denmark.

Location of the research

Hospital environment

Keywords used in the article

“Blindness, cortisol, melatonin, circadian phase, sleep” (Aubin et al., 2017, p. 515)

Data extraction concerning article number 5 (A5).

Title

Assessment of sleep in subjects with visual impairment: Comparison using subjective and objective methods

Author/year

Barbosa D. G., Andrade R. D., Santos M. O., Silva R. C. D., Beltrame T. S., Gomes Felden E. P. 2017

Objective/s

To evaluate the authentication of the results measured by objective and subjective sleep methods in case of sighted and non-sighted people.

Participants (characteristics/total number)

A group of 37 people with visual impairments participated in this research. The group consisted 19 people without light perception and vision and 18 people with low-vision conditions. The 37 participants had an ophthalmological diagnosis, they are carrying one or more of the eye syndromes that is/are classified by the International Classification of Diseases (ICD 10). A control group involved in this experiment made out of 34 sighted people. The participants divided into the following 3 groups: blind (NLP), low vision and control. All the 71 participants are residents in the southern area of Brazil and representing a population that is aged between 18 and 59.

Concept

The subjective data collection done by using PSQI and for the objective part actigraph was employed for a period of one week. These factors are placing the study design into a qualitative quantitative case control study. Sleep latency, sleep efficiency, total sleep time and various other sleep variables data were obtained for comparison.

For the statistical analysis of the collected data Shapiro– Wilk test, Kruskal–Wallis test, post hoc Dunn's test, t-test, Wilcoxon test, intra-class correlation (ICC) and Bland Altman scatter plot were conducted and SPSS software was used.

Context
Geographical location of the research

The research had been carried in a university in Florianópolis, Brazil.

Location of the research

Not specified

Keywords used in the article

"Self-reporting, sleep, vision disorders" (Barbosa et al., 2017, p. 895)

Data extraction concerning article number 6 (A6).

Title

Sleep Disturbances among Persons who are Visually Impaired: Survey of Dog Guide Users

Author/yearn

Fouladi M. K., Moseley M. J., Jones H. S., Tobin M. J. 1998

Objective/s

To exhibit the results of a survey made among guide dog users about the connection of sleep challenges and sight problems.

Participants (characteristics/total number)

1237 guide dog user answered the questionnaire. 1198 of them provided information about their visual acuity. Out of those 361 people had NLP, 420 of them had LP, 144 could notice hand gestures, 160 person could count fingers and 113 had a better overall recognition and more details than "finger counting" reference point. The mean age of the participants was 54 years (SD =15, range 17-90) in a 55/45 % male/female proportion. (Fouladi et al., 1998, p. 522) The etiology of the visual impairments of the participants are detailed in the article. It shows retinal disorders, diabetes and glaucoma on the top the list.

Concept

The researchers co-operated with the Guide Dogs for the Blind Association (GDBA) and mailed questionnaires to the subjects. It was a self-structured qualitative questionnaire with three parts, designed for visually impaired individuals. The parts obtaining information about: sleep, lifestyle and personal details respectively. The part focusing on sleep was based on the Pittsburgh Sleep Diary (1994) and the requested information concerned the previous seven days. In order to reduce bias the subject were not informed about the focus of the research.

Context

Geographical location of the research

The research had been carried out in the United Kingdom.

Location of the research

Home environment

Keywords used in the article

Not specified by the authors, formulated by the publisher as follows:

"Adults, blindness, depression, etiology, exercise, incidence, light, sleep, surveys, visual acuity". (American Foundation for the Blind, 2021)

Data extraction concerning article number 7 (A7).

Title

Decreased sleep quality in patients suffering from retinitis pigmentosa

Author/year

Gordo M. A., Recio J., Sánchez-Barceló E. J. 2001

Objective/s

This study was made to evaluate possible relations between age and gender and sleep disorders in case of patients with retinitis pigmentosa (RP).

Participants (characteristics/total number)

177 people with RP participated in this study and a control group with no sight problems consisted of 491 participants. The age spectrum here was between 10 and 80 years. Parallel a cataract study was made, there they observed 57 people without

RP but having cataracts and they were compared with a control group that had involved 190 people (age of 40±59) with no eye problems.

The subjects with disease had a diagnosis by ophthalmologist and were members of RP associations. The cataract patients were recruited from a hospital where they underwent surgery.

Concept

During pre-screening the Montgomery-Asberg Depression Rating Scale was utilised to exclude people with mental challenges. Shift-workers and people with any other eye disease than RP were excluded from this study. The PSQI survey was administered retrospectively concerning the previous month. This was a 2 years long qualitative quantitative case control study.

Context

Geographical location of the research

The research had been carried out in Spain.

Location of the research

Not specified.

Keywords used in the article

"PSQI, retinitis pigmentosa, sleep disturbance" (Gordo et al., 2001, p. 159)

Data extraction concerning article number 8 (A8).

Title

Sleep/wake cycles in the dark: sleep recorded by polysomnography in 26 totally blind subjects compared to controls.

Author/year

Leger D., Guilleminault C., Santos C., Paillard M. 2002

Objective/s

The objective of the study was to evaluate the differences of sleep patterns of 26 blind participants with NLP and those of sighted control group. In order to do so, the researchers made comparisons by collecting PSG data in normal living conditions.

Participants (characteristics/total number)

26 blind people were recruited for this research. All of them had NLP, negative pupillary reflex and negative electroretinogram profiles. In order to be eligible for participation one had to display "free-running" sleep pattern. The blind participants consisted of 7 women and 19 men with a mean age of 44.3 ± 12.1 years, aged between 26–67 years. The control group consisted 24 matched person. In the case of 2 female blind subjects aged 61 and 67 control person was not available. Neither sleep nor sight problems were present in the control group.

Concept

For this research the researchers co-operated with the Association Valentin Haüy. A survey was conducted and the subject were selected from the responders whom had NLP and had "free-running" sleep pattern. This was categorised by the International Classification of Sleep Disorders (1990).

In this qualitative quantitative case control study actigraphy and Braille sleep logs generated for 14 days and PSG recording was performed for 1 night prior to those. In addition to these PSQI survey was conducted.

In case of the blind subjects melatonin saliva and urine samples were also collected and analysed to evaluate the "free-running" sleep pattern. Urinary and salivary 6-sulfatoxymelatonin (aMT6s) samples were collected for at least 3 consecutive weeks for a period of 24 hours. In case of some subjects the samples were collected for 6 weeks. During that day saliva samples were collected every hour while subject were awake. Every 4 hours urinary sample collection repeated throughout the wake period and at the end of the night.

Every participant answered the PSQI survey. On the same day PSG data collection performed for 8 hours in laboratory settings. The following day started the actigraphy monitoring and sleep log recording.

Context

Geographical location of the research

The research had been carried out in France

Location of the research

Laboratory and home setting.

Keywords used in the article

“Blindness, free-running rhythms, sleep/wake, polysomnography, actigraphy, sleep logs” (Leger et al., 2002, s. 1607)

Data extraction concerning article number 9 (A9).

Title

Sleep characteristics of elite blind soccer players in China

Author/year

Li Ch., Wu Y., Wang X., Tang M., Suppiah H. T. 2017

Objective/s

The aim of this study to analyse the association of the sleep pattern of professional soccer player without vision and training volume. At the same time comparison was made between blind soccer players and sighted athletes concerning their sleeping characteristics.

Participants (characteristics/total number)

60 male soccer players with visual impairments participated in this survey. The mean age of the group was 22.83 years (standard deviation (SD) = 4.49). To compare their results with sighted people sleep data of athletes with no disabilities were obtained from another research conducted by Tan in 2001. In this case 163 participants were listed with the mean age of 20.81 and SD = 0.85.

Concept

In order to adjust the PSQI survey to their interest of field, four items were added. Out of these two regarding training habits (hours and frequency). The collected data contained information about: sleep quality, sleep efficiency and daytime dysfunction. It took approximately one quarter of an hour in each case to collect the data. In this qualitative quantitative case control study one-way multivariate analysis of variance (MANOVA) was used to compare training volume and sleep quality. Descriptive statistics was used to describe the age features of the subjects. Independent t-tests was conducted to compare the sleep characteristics of the people with and without sight. Cohen's d was applied to compare the group differences. These calculations were carried out in SPSS 21.0.

Context

Geographical location of the research

The research had been carried out in China.

Location of the research

Meeting room

Keywords used in the article

"Sleep, athlete, football, Paralympics, Chinese" (Li et al., 2017, p. 57)

Data extraction concerning article number 10 (A10).

Title

Relationship between melatonin rhythms and visual loss in the blind

Author/year

Lockley S. W., Skene D. J., Arendt J., Tabendeh H., Bird A. C., Defrance R. 1997

Objective/s

In this research they observed the associations of melatonin level and sight loss in humans by analysing aMT6s level from urine samples.

Participants (characteristics/total number)

49 registered blind people (13 females and 36 males) with sleep problems took part in this research represented on a scale from 19 until 72 years where the mean age was 46.1 ± 12.3 years. Two main group was created from the participants. One categorised as NLP (n=30) and the other as having LP (n=19) or even better eye-sight. (Lockley et al., 1997, p. 3763)

Concept

In this qualitative quantitative study the participants with NLP were subcategorised into 3 groups. This was to differentiate the number of photoreceptors in these groups in case 2 eyes, 1 eye or no eyes found in the body.

The PSQI survey was conducted, diagnosis of the participant's eye disease was listed after ophthalmological examination and aMT6s samples were collected and analysed. Every participant collected urine samples in a consecutive period of 3 to 5 weeks. Each week for 2 days urine samples were collected in 4-hourly intervals during the day and 8-hourly rhythm through the night. 5 ml urine sample was frozen until further aMT6s analysis.

Context

Geographical location of the research

The research had been carried out in United Kingdom.

Location of the research

The research had been carried out in home environment with no change in the lifestyle.

Keywords used in the article

Not specified by the authors

Data extraction concerning article number 11 (A11).

Title

Sleep and activity rhythms are related to circadian phase in the blind

Author/year

Lockley S. W., Skene D. J., Butler L. J., Arendt J. 1999

Objective/s

The focus of this research was to evaluate human sleep rhythm with the help of aMT6s sample analysis in the case of blind people.

Participants (characteristics/total number)

59 registered blind people with sleep problems took part in this research represented on a scale from 19 until 72 year, with 17 being female and 42 being male. The participants were divided into two groups. The first group consisted of 30 participants who were categorised as NLP and the second group consisted of 29 participants who had LP or even better eye-sight.

Concept

In this qualitative quantitative study the PSQI survey was conducted, diagnosis of the participant's eye disease was listed after ophthalmological examination, aMT6s samples were collected, sleep diaries created and actigraphs were used and analysed.

All the participants wrote a sleep and nap diary for every day for a minimal of 4 weeks. Out of 59 participants 49 wore actigraph at the same time. The data collected in this way underwent cosinor and spectral analys in Action3 software.

Every participant collected urine samples in a consecutive period of at least 4 weeks. Each week for 1 or 2 days urine samples were collected in 4-hourly intervals during the

day and 8-hourly rhythm through the night. 5 ml urine sample was frozen until further aMT6s analysis. For the data analysis One-way ANOVA was utilised.

Context

Geographical location of the research

The research had been carried out in United Kingdom.

Location of the research

The research had been carried out in home environment with no change in the lifestyle.

Keywords used in the article

"Blindness, sleep, napping, melatonin, circadian, activity, sleep disorder, advanced sleep phase syndrome (ASPS), delayed sleep phase syndrome (DSPS), free-running, non-24 hour sleep-wake syndrome" (Lockley et al., 1999, p. 616)

Data extraction concerning article number 12 (A12).

Title

Relationship between napping and melatonin in the blind

Author/year

Lockley S. W., Skene D. J., Tabendeh H., Bird A. C., Defrance R., Arendt J. 1997

Objective/s

The focus here was to identify a sleep a pattern in blind individuals and at the same time evaluate any possible connections with daytime napping.

Participants (characteristics/total number)

15 registered blind people with sleep problems took part in this research represented on a scale from 32 until 72 years, including 7 females and 8 male participants.

Concept

In this qualitative quantitative study participants with NLP were subcategorised into 3 groups. This was to differentiate the number of photoreceptors in these groups in case 2 eyes, 1 eye or no eyes found in the body. PSQI survey was conducted, diagnosis of the participant's eye disease was listed after ophthalmological examination, aMT6s samples were collected, sleep diaries created and analysed. All the participants wrote a sleep and nap diary for every day for a minimal of 4 weeks.

Every participant collected urine samples in a consecutive period of at least 4 weeks. Each week 2 days urine samples were collected in 4-hourly intervals during the day and 8-hourly rhythm through the night. 5 ml urine sample was frozen until further aMT6s analysis. For the data analysis one-way and two-way ANOVA was utilised. To investigate aMT6s results cosinor analysis was made and for nap analysis paired Student's t test was performed.

Context

Geographical location of the research
The research had been carried out in United Kingdom.
Location of the research
The research had been carried out in home environment with no change in the lifestyle.

Keywords used in the article
"Napping, sleep, melatonin, 6-sulphatoxymelatonin, blindness, human, light perception, circadian rhythms" (Lockley et al., 1997, p. 16)

Data extraction concerning article number 13 (A13).

Title
Retinal Disorders and Sleep Disorders: Are They Genetically Related?

Author/year

Murphy C., Duponsel N., Huang X.S., Wittich W., Koenekoop R. K., Overbury O. 2015

Objective/s

The aim of this study to map any possible genetic relation between retinal disorders and sleep disorders.

Participants (characteristics/total number)

107 people with a medical diagnosis of retinal disorders were recruited for this study. The age spectrum of the subjects varied between 19 and 81 years with the mean: 50.33 years. 33 of them had retinitis pigmentosa, 31 carried Stargardt's disease and 43 suffered from and age-related macular degeneration.

Concept

In this qualitative quantitative study 3 questionnaires were conducted. PSQI to evaluate general sleep quality. ESS focused on sleepiness during the day and the Brief General Health Assessment (BGHA) evaluated any other possible factors that influence sleep patterns. Genetic testing had been carried out by blood sample analyses. This helped to identify the type of retinal diseases. (Murphy et al., 2015, p. 359)

Context

Length of the research

As the PSQI is pertaining a 30 days period that is why it’s determined as a one month length research.

Geographical location of the research

The research had been carried out in Quebec, Canada and Nijmegen, Netherlands.

Location of the research

The questionnaires were conducted either personally or via the telephone in Canada. The blood samples were sent to a university in Holland.

Keywords used in the article

Not specified by the authors

Data extraction concerning article number 14 (A14).

Title

Circadian rhythm abnormalities in totally blind people: incidence and clinical significance

Author/year

Sack R. L., Lewy A. J., Blood M. L., Keith L. D., Nakagawa H. 1992

Objective/s

The aim of this research was to investigate sleep pattern disorders in blind people via blood sample analyses.

Participants (characteristics/total number)

In this research 20 blind people with NLP and 8 sighted people without medical eye issues were participating. The blind participants consisted of 6 women and 14 men with a mean age of 37.86 ± 6.0 years. The control group consisted of 5 women and 3 men with a mean age of 31.7 ± 12.9 years.

Concept

During this qualitative quantitative case control study sleep diaries were recorded and blood samples were taken for further analyses. Melatonin (n = 20), cortisol (n = 4) and sleep propensity (n = 1) values were taken from blood samples. Every second week for one day in every hour blood melatonin samples were collected from the participants over a 6-week period. (Sack et al., 1992, p. 127)

Context

Geographical location of the research

Oregon, U.S.A.

Location of the research

Hospital and home environment.

Keywords used in the article

Not specified by the authors

Analysis and Presentation of results

Below are some remarks concerning the length of the periods of the research. In case of no comment the period reflects exactly the indicated time in table 1. year refers to year of publication of the article.

Article number (year)	Period of time	Article number (year)	Period of time
A1 (2010)	30 days	A8 (2002)	14 days
A2 (2016)	30 days	A9 (2017)	30 days
A3 (2018)	3 days	A10 (1997)	3-5 weeks
A4 (2017)	30 days	A11 (1999)	3-5 weeks
A5 (2017)	7 days	A12 (1997)	30 days
A6 (1998)	7 days	A13 (2015)	30 days
A7 (2001)	2 years	A14 (1992)	6 weeks

Table 1. displays the length of the research.

In the cases of A1, A13, A14 and A18, PSQI concerns the previous 30 days from the date of the survey was conducted. It does not mean that the length of the study was carried out for 30 days. It reflects the period that was analysed.

In the case of A3, participants spent two consecutive nights at the sleep centre, however only results from the second night were included in the experiment. Parts of the research were done on a separate day and that is how it adds up to 3 days.

In the case of A6, a survey was posted that collected information about 7 days retrospectively from the date of the survey was conducted.

In the case of A7, for a period of 2 years, in different seasons, the PSQI survey was conducted over a period of 30 days retrospectively.
In the case of A10, urine samples were collected for a consecutive period of 3 to 5 weeks. Each week for 2 days urine samples were collected in 4-hourly intervals during the day and 8-hourly intervals during the night.

In the case of A11, urine samples were collected for a consecutive period of 3 to 5 weeks. Each week for 1 or 2 days urine samples were collected in 4-hourly intervals during the day and 8-hourly intervals during the night.
In the case of A14, every second week for one day in every hour, blood melatonin samples were collected from the participants over a 6-week period. They collected 3 days worth of data over the period of 6 weeks.

Quantity	Period of time	Quantity	Period of time
1	3 days	2	3-5 weeks
2	1 week	1	6 weeks
1	2 weeks	1	2 years
6	30 days	X	X

Table 2. shows the frequency of the preferred period of time of a research.
On average a 4-6 weeks research period was preferred by the specialist. In 8 cases this length of time was used, that is 57 % of the total (Article number A7 and A14 are not included in this calculation as they are not representing a regular pattern).

Article number (year)	Methods	Article number (year)	Methods
A1 (2010)	PSQI	A8 (2002)	urin melatonin, salivary melatonin , PSQI, sleep logs, actigraph, PSG
A2 (2016)	PSQI, actigraph	A9 (2017)	PSQI

A3 (2018)	PSQI, PSG	A10 (1997)	urin melatonin, PSQI
A4 (2017)	cortisol salivary, melatonin salivary, PSQI	A11 (1999)	urin melatonin, PSQI, sleep logs, actigraph
A5 (2017)	PSQI, actigraph	A12 (1997)	urin melatonin, PSQI, sleep logs
A6 (1998)	PSQI	A13 (2015)	Blood for genetic testing, PSQI
A7 (2001)	PSQI	A14 (1992)	Blood samples for melatonin, cortisol and sleep propensity

Table 3. lists the different methods utilised during the research. Year refers to year of publication of the article.

PSQI and other questionnaires were used in 13 cases, or 92%. PSQI on its own was utilised in 4 cases, which is 28 %. Urine sampling was used in 4 cases, saliva collectionin 2 cases and blood sample analysis in 2 cases. In 3 cases separate sleep logs were written. Actigraph was utilised in 4 cases. PSG was the preferred investigation method in 2 cases.

Concerning the eye conditon of the focus group 10 cases investigated only blind people. In 2 cases people with low vision took part in the research and in 2 cases blind and low vision participants were analysed at the same time. Half of the research cases (n=7) used control groups during the evaluation.

Article number (year)	Country	Article number (year)	Country
A1 (2010)	Nigeria	A8 (2002)	France
A2 (2016)	Denmark	A9 (2017)	China
A3 (2018)	Denmark	A10 (1997)	United Kingdom
A4 (2017)	Denmark	A11 (1999)	United Kingdom

A5 (2017)	Brazil	A12 (1997)	United Kingdom
A6 (1998)	United Kingdom	A13 (2015)	Canada and Holland
A7 (2001)	Spain	A14 (1992)	U.S.A.

Table 4. shows the proportion of the different countries represented in this scoping review.

Four of the research cases (28%) were conducted in the UK, three (21%) were conducted in Denmark and seven (50%) were took places in other countries.

3 Results

Search results

A1.

81.2% of the research subjects reported sleep-wake disorders and 49.4% of those had it at a significant level. The PSQI score over 5 indicates sleep problems. In this study scoring over 9 points were considered as a significant sleep disorder. Whilst PSQI score for the participants with no light perception were 9.6, the score for the rest of the blind participants were 8.0. Day time napping was reported by 65.9% of the participants, making it the most common sleep disorder amongst the group. The members of the napping group (n = 112) suffered from cataract (n = 41), glaucoma (n = 33), optic atrophy (n = 8), uveitis (n = 2) and other eye diseases. In the study group (n=170), 73 cases of short sleep (less than 5 hours) and 53 cases of interrupted sleep were reported. Statistical significance was found between blindness and sleep-wake disorder (p=0.009 and 0.007).

A2.

For the evaluation of sleep quality, PSQI survey was utilised. This study group had 11 blind participants. 7 (63%) out of those scored more than 5 points at PSQI survey, indicating the presence of sleep disturbances in blind people. At the same time from the same number of sighted control group (n = 11), only 3 scored above 5 PSQI points. From the blind group, 4 participants (36%) reported mild sleep disturbance and 3 participants (27%) reported severe sleep disturbance. The remaining 4 blind participants (36%) scored just under 5 PSQI points (n=4), categorising them as having no sleep disturbance. In this study, the PSQI scores categorised as: mild between 6 and 8 scores and severe above 12 scores. Concerning sleep efficiency on the 30 days length of the study, the sighted and the blind group did not show significance differences on average. However, there were bigger variations of the “time spent in bed” and “duration of sleep” scores between the groups during this one month. This group of researchers agreed to previous finding, that the issue of reduced quality of sleep amongst the blind were more significant in comparison to average sighted people.

A3.

Out of the 11 recruited blind participants, the data of 10 people was analysable. Due to some technical issues, one person's data could not be included in the experiment. In order to determine the circadian phase, melatonin onset (MO) was measured in the human body. 50% of the blind subjects displayed a desynchronised MO timing. This figure in the sighted group was 18%. At times when MO started at ordinary time, sleep structure displayed the same pattern in sighted and non-sighted people. In case of regular MO timing sleep parameter, differences were not recorded between congenital blind people and people who became blind later in life. Balanced circadian rhythms was observed in case of 50% of the participants without vision (n = 5) and 82% in the control group (n = 9). In case of delayed, shifted or uncategorisable timing of MO larger REM, increased wake times occurred. Concerning sleep duration, significant difference was recorded between the sighted and blind group. The length of the sleep on average was shorter among the participants of the blind group. Between the 10 blind participants and control group, irregular circadian phases were observed more frequently in cases of blind people (n = 5) than people with no sight problems (n = 2).

A4.

Out of the 11 recruited blind participants, the data of 10 people was analysable. Due to some technical issues, one person's data could not be included in the experiment. A higher concertation level of melatonin was observed in blind individuals (value = 5) during one day long experiment. In case of sighted people, the melatonin value was 9. Blind individuals with higher level of melatonin in their body scored higher in the PSQI survey and displayed sleep disorders accordingly. Cortisol is also one of the sleep indicator. Cortisol samples taken from sighted (v = 7) and blind individuals (v = 8) did now show significant differences. These results corresponded with previous researches where NLP blind people displayed irregular circadian rhythms. The irregular MO timing

observed in blind people during this research correlated with previous hypothesis from other experts that associates irregular circadian rhythms with blindness.

v = value

A5.

Sleep duration measured by objective (articgraph) and subjective (PSQI) methods displayed different results in case of the blind participants with NLP. Shown in table 5. Concerning the PSQI survey, the results of blind subjects showed higher figures compared to the sighted group. Below demonstrated in Table 5. with the details of sleep latency.

Group	Describes	PSQI (subjective)	Articgraph(objective)
Blind	Sleep durations (hrs)	5.67	6.48
Low vison	Sleep durations (hrs)	6.39	6.60
Control	Sleep durations (hrs)	6.84	6.80
Blind	Sleep latency (minutes)	50.37	5.47
Low vison	Sleep latency (minutes)	31.44	5.18
Control	Sleep latency (minutes)	19.41	5.16

Table 5. Shows part of the PSQI and Articgraph results from table 2 in article number 5.

A6.

20% of the guide dog users who answered the survey reported poor or very poor sleep quality. 10% of the subjects reported more than 1 nap during the day. Connection was found between better sleep and exercise. 7% of the respondents had no daily exercise, 8% did sports and the majority 84% had more than 10 minutes exercise per day on average. The researchers concluded that depression in blind people resulted in poorer sleep. 47% of the poor sleepers claimed to be depressed. Connection between sight quality and sleep quality was not proven. 74% of the NLP group from the survey reported a decent, good or very good sleep.

A7.

During this research, the present of sleep disorders were reported by RP patients and control subjects scored 5 or higher PSQI points. Significantly higher values of sleep disorders were found among the RP patients than among the control group. In comparison between the RP subjects and the control group, the RP subjects reported reduced level of sleep quality and sleep efficiency, higher frequency of ineffectiveness during the day, fewer sleeping hours and longer sleep latency. Aging was deemed a significant factor which worsened sleep quality both among those in controls and RP patients. Sleep quality differences between groups noticeably took turn for the worse in case of the RP patients from the age of 40 onwards. Gender held no influence over the result of PSQI in both groups at any age. The presence of cataract in the body did not affect the scored PSQI values in any groups, be it the control group with subjects with cataract or the control group with subjects with RP and with or without cataract.

A8.

The observed blind participants demonstrated abnormal circadian rhythm despite normal social circumstances. Daytime napping was recorded by actigraph among blind participants. Compared to the control group, the blind group had significantly lower total scores at sleep latency, sleep efficiency, length of sleep and total REM sleep as shown in table 6.

PSG index	Blind group	Control group
Sleep latency (min)	27.33	12.16
Sleep efficiency (%)	76.2	92.3
Total sleep time (min)	289.7	424
REM (%)	12	23.7

Table 6. Shows part of the PSG results from table 3 in article number 8.

Sleep time differences between working and non-working blind group were clearly noticeable. The working blind participants used slightly more time to sleep (314 min.) compared to the non-working blind group (242 min). Cases of different causes of blindness (such as blindness since birth, acquired blindness, person with biocular prosthesis or person with presence of disfunction eye) did not produce different result during night time sleep pattern and abnormal circadian rhythm observation.

Every participant (n = 26) scored more than 5 in the PSQI survey displaying sleep problems. According to the PQSI scores, 23% of the blind participants reported mild

sleep disturbances, 34.6% of the blind participants reported moderate sleep disturbances and the majority of blind participants 42.4% reported severe sleep disturbances. On average the blind group scored 10.9 on the PSQI survey. Further details regarding this can be found in Table 7.

PSQI category	Blind participants nr.	Percent
mild sleep disturbance	6	23%
moderate sleep disturbance	9	34.6%
severe sleep disturbance	11	42.4%

Table 7. PSQI score results of the blind participants from article number 8.

A9.

Based on the PSQI scores, 26.7% of the blind group fell into the “poor sleeper” category. The amount of exercise done by the individuals from the poor sleepers (n = 14) and good sleepers (n = 46) category within the blind group was noticeably different. Those who trained 16.44 hours per week scored to be a poor sleeper and 21.10 hours of training per week placed the blind participants into the “good sleep” category. According to the report made by the blind group, the average sleep duration was 7.94 hours, the average sleep latency was 0.54 hours and the average efficiency of sleep was 90.1%. On a total average, the 60 blind football players scored lower (4.42) in the PSQI survey compared to the 160 sighted athletes (6.98). Blind football players scored higher in sleep latency when compared to sighted athletes. Other PSQI sleep characteristics scores (sleep duration, sleep efficiency, sleep disturbance, daytime misfunction) were lower among the blind group in comparison to the control group.

A10.

The average PSQI score of the participants was 8.4 and the mean age was 46.1. Age did not cause any difference in PSQI score, both in LP and NLP group despite significant age difference between the two groups. The mean age of LP group was 41.7 years and the NLP group 48.9 years. A one day measurement of aMT6s output was done on both LP and NLP groups with no significant difference in results. Age did not cause significant differences on the output of aMT6s. However a tendency of less amount of output production was noted with progressing age. Gender differences had no significant

effect on the daily output of aMT6s. 94% (n = 18) of the participants with LP presented a significant pattern in aMT6s production created by cosinor analysis.

As summarised in Table 8., most of the LP subject 14 (74%) had a normal circadian rhythm. In the case of one of the LP subjects (5%), the circadian rhythm could not be classified. The rest of the LP group 4 (21%) identified with abnormal circadian rhythm. Out of the 30 NLP participants, it was possible to categorise the circadian rhythm based on aMT6s production level in 29 cases (96%). The 3 different subgroups of the NLP participants displayed different circadian rhythms. The NLP group was categorised by the number of eyes present in the subject's body such as: 2, 1 or 0 eye present. The frequency of the free running circadian rhythm was much higher in the NLP participants with one (71%) or with no eye present in the body (91%) than in NLP participants with 2 eyes present in the body (17%). In the case of one of the NLP subjects (3%), the circadian rhythm could not be classified. Out of the total 30 participants of the NLP group, 7 individuals (23%) had normal circadian rhythm, 5 (17%) had abnormal and 17 (57%) showed free running circadian rhythm.

LP type	Normal	Abnormal	Free	Unclassified	Total
LP sum	**14 (74%)**	**4 (21%)**	**0**	**1 (5%)**	**19 (100%)**
NLP - 2 eye	4 (33%)	5 (42%)	2 (17%)	1 (8%)	12 (40%)
NLP - 1 eye	2 (29%)	0	5 (71%)	0	7 (23%)
NLP - 0 eye	1 (9%)	0	10 (91%)	0	11 (36%)
NLP subtotal	**7 (23%)**	**5 (17%)**	**17 (57%)**	**1 (3%)**	**30 (100%)**
LP+NLP total	21	9	17	2	49 (100%)

Table 8. Shows LP and NLP subjects circadian rhythm types taken from Table 3. in article number 10.

In the light perception and disease correlation analysis, only participants with eyes present in the body (n = 38) were included. This is due to the fact that the absence of eye would prevent the collection of information concerning LP. 37% (n = 14) of this group experienced a form of RP. 78% (n = 11) of the RP patients showed a regular pattern of the circadian rhythm and 21% (n = 3) displayed irregular circadian rhythm. In 7 cases (18%), retinal detachment was observed. In this group, 2 participants had

normal circadian rhythm, 4 had abnormal circadian rhythm and 1 had free running circadian rhythm.

A11.

Napping during the day indicated a subtle signal of problems with aMT6s rhythm. aMT6s concentration level measurements from urine revealed that 30 (53%) participants with normally entrained (NE) aMT6s had less naps and for a shorter length of time in comparison to participants with abnormally entrained (AE) (n=9, 16%) or free-running (FR) aMT6s rhythms (n=17, 30%). Napping had a rhythm related to aMT6s acrophase and it occurred within 5 hours plus minus to that. 25 participants with AE and FR recorded 65% more naps in the period of 5 hours earlier or later to aMT6s acrophase in comparison to that which was outside that time frame. In case of AE participants, a persistent early or late aMT6s timing was observed. Longer sleep period at night and fewer number and shorter period of napping during the day was observed among the FR participants. 5 participants (8%) admitted to avoid napping during the research.
Article 11 referred to article 10 for more details regarding aMT6s rhythm observed earlier on the same 49 subjects. 2 participants with unclassified aMT6s rhythm (UN) were excluded from aMT6s inspection and one FR subject could not provide urine samples. Consequentially, these 3 subjects were not included in every analysis of article 11. 10 participants (20%) showed FR sleeping patterns (based on figures from: nap, activity, sleep starting time and finishing time of sleep) but did not displayed FR aMT6s rhythm. 39 participants (NE = 30, AE = 9) demonstrated a stable aMT6s rhythm entering to the 24 hours circle. Synchronicity between aMT6s rhythm, sleep onset and sleep duration was observed. In case aMT6s rhythm was ahead of the normal time, sleep onset started earlier and length of the sleep was extended thought the night. When aMT6s rhythm happened later than normal, sleep onset also started later and length of the sleep was reduced though out the night. According to these timings, there were 2 definitions in the professional literature: 1. advanced sleep phase syndrome (ASPS), 2. delayed sleep phase syndrome (DSPS). Based on these two categories, 3 person had ASPS and 5 had DSPS from the AE group (n=9). There was one exceptional subject

whose advanced aMT6s acrophase was recorded and relatively delayed mean sleep start within the same phase.

Observation was done in the FR group and it was concluded that the length of the daytime napping and sleep during the night was affected by the changes in the aMT6s rhythm. The length of sleep during the night was the shortest when aMT6s rhythm was out of phase, and the longest when aMT6s rhythm was in normal phase. The frequency and the length of naps during the day was the greatest when the aMT6s rhythm was out of phase at a maximal point and napping was significantly reduced when aMT6s rhythm was in normal phase. The activity rhythm's relation to aMT6s phase demonstrated the same pattern as in the case of sleep length during the night. Sleep latency, night awakenings, total sleep length (sleeping at night + napping at day) and subjective sleep quality were not significantly affected by the aMT6s phase.

In the case of 49 participants, spectral analysis was done concerning the rhythms of activity. Most of the NE participants (71%) had one spectral peak, others (AE = 78% , FR =71%) with irregular aMT6s rhythm had several spectral peaks.

A12.

Out of fifteen NLP participants, nine had FR aMT6s rhythms, three had AE and three had NE rhythms. Five of the subjects with FR aMT6s rhythms had no eye present in the body. Three of the subjects with FR aMT6s rhythms had one eye present in the body. Two subjects with one eye present in the body displayed NE aMT6s rhythms. Among the participants who had two eyes present in the body, one person had NE, three participants had AE and one subject had FR aMT6s rhythms. Table 9. shows the summary of it below.

Pathology (P.)	Normal	Abnormal	Free	Total of P. groups
NLP - 2 eye	1 (20%)	3 (60%)	1 (20%)	5 (100%)
NLP - 1 eye	2 (40%)		3 (40%)	5 (100%)
NLP - 0 eye			5 (100%)	5 (100%)
Total of rhythms	3 (20%)	3 (20%)	9 (60%)	15 (100%)

Table 9. Shows the aMT6s rhythm variations among the participants with different pathology.

86% of them (n = 13) had naps during the day, in two cases napping was not registered but it was purposely avoided by the subjects. The length and the frequency of the naps showed higher figures in case of AE participants in comparison with NE aMT6s rhythms subjects. Only in the case of FR aMT6s rhythms participants were FR nap patterns observed. The peak level of aMT6s corresponded with the napping time of the AE aMT6s rhythms participants (n = 2). Within four hours prior and after the calculated aMT6s acrophase, the frequency of naps significantly increased. In the case of normal aMT6s phase (from midnight until 6 a.m.), the length of sleep was longer and napping lasted shorter and occurred less frequently. The beginning and the end of the sleep changed in the same direction in synchrony of the advance and the delay of the aMT6s rhythm.

According to PSQI survey, the 3 main reasons for sleep disorder among the participants are: shorter sleep at night, inadequate sleep quality and sleepiness during daytime. Age did not influence the PSQI scores of the participants.

A13.

The 33 participants with RP 21 (64%) who scored 5 or higher in the PSQI survey were categorised as those with poor sleep quality. Based on the PSQI scores of participants with Stargardt's disease (SDD), 48% of the group were poor sleepers and 53% were [with] age-related macular degeneration (AMD) [which] belonged to the same sleep category. RP and SDD patients scored the highest in sleep latency, subjective sleep quality and sleep disturbance in the PSQI survey. In the case of AMD patients, sleep disturbance, habitual sleep efficient and sleep duration scored highest in the PSQI survey. In the Epworth Sleepiness Scale (ESS) survey, 21% of the RP subjects, 16% of the patients with SDD and one person with AMD reported sleepiness during the day. Age affected neither the PSQI scores, nor in the ESS survey's scores in the case of RP and SDD participants.

The RP patients were grouped according to mutation types in their eyes. 20 of the subjects had mutations only in the retina and 13 had mutations in the retina and in the pineal glands at the same time. Participants with mutation in two places reported

higher scores in the poor sleeper category of the PSQI survey when compared to those participants who had mutations only in the retina. At the same time, the mean score of the 2 groups gave the same results. ESS survey reported that participants with mutation only in the retina scored higher in the sleepiness during the day. There was no significant score difference between the 2 mutation groups in both of the surveys. The comparison of the scores in the ESS showed that ADM group there was a prominent difference between the RP and the SDD group. At the same time, the ESS results of the RP and the SDD group did not show significant difference.

Remark by the author: The poor sleep quality PSQI score of the RP participants indicated as 56% in the abstract of this article. The same PSQI score of the RP participants marked as 64% in the result: Phase I section and in Table 3. The author is using number 64 in her analysis, as it's 2 times more present in the article.

A14.

The melatonin onset comparison between 11 FR blind participants and 8 NE sighted subject showed significantly different pattern. The pattern of the FR subjects had a stable and precise rhythm. The circadian period of the blind participants with FR pattern varied from subject to subject between 23.86 – 25.08 hours (mean 24.55). 3 out of the 20 participants had UN melatonin pattern, thus further data was not calculated from figures collected from them. Among the blind participants, 3 had NE melatonin onset and 3 had AE melatonin onset. The experiment was expanded for a half a year with some of the FR subjects. During this period, the FR melatonin rhythm remained stable and was not influenced by the surrounding social rhythm. Cortisol samples were taken from 4 FR participants. On a daily scale span, the lowest point of the cortisol concentration was during regular sleeping hours (12 a.m. – 02 a.m.) and the peak was during the active period of the day (11 a.m. – 01 p.m.)

Remark by the author: The researcher performed 3 individualised analyses among the tests. Those 3 were not specified here because case-studies were excluded in the selection of the articles for the scoping review.

Review findings

The results are listed in an alphabetical order by the author of the articles in the tables below.

In Table 10. below the PSQI survey, components that were most referred to in the articles are listed. Reduced sleep duration was stated in 6 articles (article nr. 3, 7, 8, 9, 11, 12) and was the most common sleep problem. Sleep latency was the second most mentioned (n = 5) sleep problem among visually impaired and blind people as it was referred to in article nr. 7, 8, 9, 11, 13.

In 6 of the articles (article nr. 1, 2, 8, 9, 10, 13) it was mentioned that the PSQI score of the subjects was over 5. In 5 cases it concerned over 60 % of the study population. In the case of article nr. 9 it only effected less than 30% of the blind subjects. In this one case, detailed pathology of the subjects was not provided.

Furthermore, in 3 articles (nr. 1, 2, 8), the PSQI score recorded was over 12, indicating severe sleep problems in the visually impaired participants. Both sleep quality (in article nr. 7, 12, 13) and sleep efficiency (in article nr. 7, 8, 9) which were part of the survey were analysed in more details in 3 articles. One of the PSQI sleep components is defined as “daytime dysfunction” ref: A18-13 which was referred to as a problem for people with sight problems in article nr. 7 and 12. In other articles (nr. 1, 6, 8, 11) the term “daytime napping” was used as a sleep problem. During my analysis, I considered these two categories as one.

Article	Sleep duration	Sleep quality	Sleep efficiency	Daytime dysfunction	Sleep latency	Sleep disturbance	PSQI over 5	PSQI over 12
1							81.2%	49.4%
2							63%	27%
3	X							
7	X	X	X	X	X			
8	X		X		X		100%	42.4%
9	X		X		X		26.7%	
10							X	
11	X				X			
12	X	X		X				
13		X			X	X	64%	

Table 10. Lists the PSQI sleep component aspects of the results and their frequency in the articles.

Article	Out of phase	NE LP	AE LP	FR LP	NE NLP	AE NLP	FR NLP
1							
2							
3	X						
4	X						
5							
6	X						
7	X						
8	X						
10		74%	21%		23%	17%	57%
11		X	X	X	X	X	X
12					20%	20%	60%
14					15%	15%	55%

Table 11. Lists the circadian rhythm aspects of the results and their frequency in the articles.

The 14 analysed articles used various aspects in their researches. Below different points that were emphasised in connection of the research question are displayed.

In 5 cases (nr. 1, 10, 11, 12, 14) the researchers considered light sensitivity as an important part of the experiment and sorted the subjects accordingly.

Daytime napping and disfunction were mentioned and measured in 6 cases (nr. 1, 6, 7, 8, 11, 12) as a significant factor and an indicator of sleep disorders.

The column named: “No difference pathology” refers that no differences in pathology influenced the results in three cases. In article nr. 2, 3 and 8 it was mentioned that the results were not influenced by the cause of the blindness. People who were born blind or became blind later on in life did not produce different scores during PSG (article nr. 3) or actigraphy (article nr. 2 and 8) measurements. As McCall & McCall observed in their research, PSG and actigraph was producing roughly 95% which was the same values. Therefore, these three articles are placed in the same category here. (McCall & McCall, 2012, s. 122)

2 articles (nr. 6 & 9) emphasised the connection of physical activity and sleep quality in case of blind subjects.

Article nr. one, 7 and 10 did not find gender aspect reflected in the PSQI scoring. In case of article nr. one, 12 and 13, the age aspect of the PSQI scores was not correlated with any specific eye disease.

Article	LP/NLP considered	Napping	No difference pathology	Sleep & sport	Gender irrelevant	Age irrelevant
1	YES	65.9%			YES	YES
2			YES			
3			YES			
6		10%		YES		
7					YES	
8		YES	YES			
9				YES		
10	YES				YES	
11	YES	YES				
12	YES					YES
13						YES
14	YES					

Table 12. Lists different aspects of the results and their frequency in the articles.

4 Discussion

Here I discuss the collected articles in the light of the research question: “What is the reported association between visual impairment and sleep in adults?”.

The importance of the PSQI survey is pronounced in this review as it is at the forefront of the analysed articles. To gain a wider understanding, two thirds of the research projects utilised other methods parallel to PSQI. I would like to draw attention to how the PSQI survey requests information about the sleeping habits of the subjects over the previous 30 days. Article nine stated that each participant spent approximately 15 minutes to answer the survey. This subjective data collecting method allowed less precise data to be present in the research. Due to their lack of vision, blind people do not necessarily check what time they go to bed as a sighted person might do and might recall it during the PSQI survey. The PSQI survey can provide more precise data when conducted at the time of the research and possibly accompanied with a sleep log.

The high number of PSQI scores in the studies are also observed. In comparison with the sighted controls over a one month period of time, the visually impaired participants had a variation of sleep efficient throughout those nights, in contrast to the stable sleep efficiency among the sighted control group. These observations are similar to the ones made in Japan by Tamura and his colleagues described as follows: “In this study, the rate of individuals reporting irregular sleep– wake pattern, difficulty maintaining sleep and daytime sleepiness were significantly higher in visually impaired participants than in control subjects.” (Tamura et al., 2016, p. 1664)

Concerning the PSQI scores, category names and the boundaries of the categories were adjusted in a few particular cases according to the judgement of the researchers (articles one and two). This made the comparison less unified. Using standard PSQI categories would enable specialists to compare results more effectively.

The nuances of the different eye conditions resulted in significance differences in the sleep results of the subjects. The experiments where the light sensitivity of the eye was considered could mean better defined results about the connections of the sleep pattern and the eye condition of the participants. As the amount of light triggers and influences the circadian rhythm, some research had the focus on this particular aspect. Evaluating and measuring the light properties in the body appears as a favourable step

to take for this type of analysis.

Daytime napping was also a frequently mentioned and analysed as part of this research. There were two almost identical research teams in articles eleven and twelve, which were conducted rather similarly with subjects with similar conditions. In one article, the napping among the subjects occurred within 5 hours, in the other article within 4 hours from melatonin peak or crest. Both articles pointed out the synchronicity between occurrences of napping and melatonin rhythm. Day time napping is most probably an indicator of the free running circadian system that is out of synchrony. (article 2 and 12)
The connection between physical training and sleep quality was the focus in two articles. In earlier studies from 2014 Ramos and his colleagues mentioned that exercise could affect sleep duration (Ramos et al., 2014, p. 4). One of the articles conducted the research among guide dog users. Among the guide dog users, only 20% complained of "poor sleep quality" (article six). This result was significantly different from the other 12 articles. As it is described by Oka & Shibata, dogs can lead to a significant increase in the exercise levels of their caretaker (Oka & Shibata, 2009, s. 412). This suggests that guide dog users could be considered as a separate category within the blind group when analysing sleep quality.
The articles revealed how the technology used in this area of research developed over time. Article fourteen from 1992 mentioned that there were a limits on experiments using blood samples as anaemia had to be considered and avoided among the subjects. Since then, throughout the years urine samples were commonly taken to measure cortisol and melatonin levels. In an article from 2017, saliva samples were used for the same purpose. This method provides a simple and safe method of examination and reduces the research periods significantly. To balance the out of rhythm circadian rhythm, the use of melatonin is suggested by the researchers such as Sack and his colleagues (Sack et al., 2000, p. 1070).
Articles number two, three and four were written mostly by the same author with almost the same research team members. In these three articles different objective methods were used and all of the articles pointed directly towards the connection of sleep difficulties and blindness.

Some of the studies considered depression as a contributor to the sleep difficulties (1, 2, 6). Explaining more about the external factors that could also influence and eventually disturb the human body's own sleeping system.

Among subjects with NLP, the sleep disorders can be related due to the lack of light that creates a FR circadian pattern as Flynn-Evans and colleagues also wrote about it in 2014. (Flynn-Evans et al., 2014, p. 218) From these articles, the previously observed aspect gained reassurance that in case of blind people the observed free-running circadian rhythm can cause sleep disorders.

The majority of these articles pointed towards the sleep issues that people with sight problems has to endure on a daily base. A visual impairment is more noticeable than a sleep disorder. By bringing this silent struggle to light, there is a higher chance that the affected people would be better understood. Furthermore, affected individuals can adjust more easily to their daily schedule or work routine around the known sleep rhythm.

5 Conclusion

By selecting and analysing these fourteen articles and creating a scoping review, an insight of the association between visual impairment and sleep was gained. All of the articles pointed towards the association between visual impairments and sleep. Approximately one fourth of the research focused on the connection between visual impairment and sleep disorders. Another quarter of the research approached the sleep problems that visually impaired people are facing from a light sensitivity point of view. One fifth of these articles analysed the sleep quality in relation to activity and exercise perspective withing the blind community. The remaining articles had unique focus point, from a specific eye disease (RP) or gene related analysis. Variabilities in sleep efficiency suggested sleep disturbance in visually impaired people.

Overall this scoping review also found that previous research mentioned by Leger about the connection between the reduced amount of light that reaching the pineal gland in the brain and higher presence of sleep disorder (Leger et al., 1999, p. 198).
PSQI survey that was used widely among the researchers. The survey made the impression to function more as a general tool to give an idea about probable sleep disorders but not precise enough to go into details concerning sleep related problems. In order to gain a comprehensive and detailed data to improve the lives of the people with visual impairment, objective study methods are recommended.
It has been observed that sleep disorder is an existing problem within the visually impaired group. Especially among blind people, the free-running circadian rhythm can be related to sleep problems (article four.) The higher melatonin concentration in the body of blind people influences the circadian rhythm and can cause irregular pattern. These findings are well reflected on the PSQI scores of the blind subjects.
Another aim of this study was to raise more awareness about the sleeping challenges visually impaired people are facing. By promoting awareness among the common people about the sleeping problem among the blinds, individuals who work with the blinds has the chance to provide better services to their visually impaired clients. The consciousness about the connection of sleep disorders and visual impairment could be included in the everyday practise of the specialist who are working with the subjects.

Armed with this knowledge the specialists can adjust and suite their interactions with the visually impaired participants to improve their quality of life.

In terms of future research possibly, the scoping review can be done also with other keywords to gain another aspect of the field. Since melatonin is an essential part of sleep process, the next step perhaps could be to look into melatonin based medications and a summary of the effects they have on the blind people with sleep disorders. In order to observe the sleep pattern of visually impaired people, a longer period of observation is recommended. Perhaps a one week period of observation and sample collection gives more opportunity to analyse and probably preferable over the 24 hours experiment.

References/bibliography

Adeoti, C., & Akang, E. E. (2010). Disorders of the sleep-wake cycle in blindness. *West African journal of medicine*, *29*(3), 163–168. 10.4314/wajm.v29i3.68214

American Foundation for the Blind. (2021). *Sleep Disturbances among Persons who are Visually Impaired: Survey of Dog Guide Users.* SAGE Journals. https://journals.sagepub.com/doi/abs/10.1177/0145482X9809200712

Aubin, S., Gacon, C., Jennum, P., Ptito, M., & Kupers, R. (2016). Altered sleep-wake patterns in blindness: a combined actigraphy and psychometric study. *Sleep medicine*, *24*, 100–108. https://doi.org/10.1016/j.sleep.2016.07.021

Aubin, S., Jennum, P., Nielsen, T., Kupers, R., & Ptito, M. (2018). Sleep structure in blindness is influenced by circadian desynchrony. *Journal of sleep research*, *27*(1), 120–128. https://doi.org/10.1111/jsr.12548

Aubin, S., Kupers, R., Ptito, M., & Jennum, P. (2017). Melatonin and cortisol profiles in the absence of light perception. *Behavioural brain research*, *317*, 515–521. https://doi.org/10.1016/j.bbr.2016.09.060

Barbosa, D. G., Andrade, R. D., Santos, M. O., Silva, R., Beltrame, T. S., & Gomes Felden, É. P. (2017). Assessment of sleep in subjects with visual impairment: Comparison using subjective and objective methods. *Chronobiology international*, *34*(7), 895–902. https://doi.org/10.1080/07420528.2017.1331355

Flynn-Evans, E. E., Tabandeh, H., Skene, D. J., & Lockley, S. W. (2014). Circadian Rhythm Disorders and Melatonin Production in 127 Blind Women with and without Light Perception. *Journal of biological rhythms*, *29*(3), 215–224. https://doi.org/10.1177/0748730414536852

Fouladi, M. K., Moseley, M. J., Jones, H. S., & Tobin, M. J. (1998). Sleep Disturbances among Persons who are Visually Impaired: Survey of Dog Guide Users. Journal of Visual Impairment & Blindness, 92(7), 522–530. https://doi.org/10.1177/0145482X9809200712

Gordo, M. A., Recio, J., & Sánchez-Barceló, E. J. (2001). Decreased sleep quality in patients suffering from retinitis pigmentosa. *Journal of sleep research*, *10*(2), 159–164. https://doi.org/10.1046/j.1365-2869.2001.00251.x

Hawkins, J. (2018, July 15). *Pittsburgh Sleep Quality Index (PSQI)* Goodmedicine http://www.goodmedicine.org.uk/files/assessment,%20pittsburgh%20psqi.pdf

Joanna Briggs Institute. (2020). *11.1 Introduction to Scoping reviews.* JBI. https://wiki.jbi.global/display/MANUAL/11.1+Introduction+to+Scoping+reviews

Klein, A.E. (2019.) *What do we know about so far between the connection of sleeping difficulties and visual impairment at humans? Systematic Review Protocol.* [Assignment] University of South-Eastern Norway

Klein, A.E. (2019.) *Light to the eye, A systematic review about the connection of sleeping difficulties and visual impairment.* [Assignment] University of South-Eastern Norway

Klein, A.E. (2020.) *Summary of my master project, Working title: visual impairment and irregular sleep patterns.* [Assignment] University of South-Eastern Norway

Klein, A.E. (2021.) *What is the reported association between visual impairment and sleep in adults? – a scoping review*, *Abstract.* [Assignment] University of South-Eastern Norway

Leger, D., Guilleminault, Ch., Defrance, R., Domont, A. & Paillard, M.(1996). Blindness and sleep patterns. *The Lancet*, 348(9030), 830-831. https://doi.org/10.1016/S0140-6736(05)65256-7

Leger, D., Guilleminault, C., Defrance, R., Domont, A., & Paillard, M. (1999). Prevalence of sleep/wake disorders in persons with blindness. *Clinical science*, *97*(2), 193–199. https://pubmed.ncbi.nlm.nih.gov/10409474/

Leger, D., Guilleminault, Ch., Santos, C. & Paillard, M. (2002). Sleep/wake cycles in the dark: sleep recorded by polysomnography in 26 totally blind subjects compared to controls. *Clinical Neurophysiology, 113*(10), 1607-1614. https://doi.org/10.1016/S1388-2457(02)00221-3

Li, Ch., Wu, Y., Wang, X., Tang M. & Suppiah, H. T. (2017) Sleep characteristics of elite blind soccer players in China, Biological Rhythm Research, 48(1), 57-64, 10.1080/09291016.2016.1228573

Lockley, S. W., Arendt, J., & Skene, D. J. (2007). Visual impairment and circadian rhythm disorders. *Dialogues in clinical neuroscience*, *9*(3), 301–314. https://doi.org/10.31887/DCNS.2007.9.3/slockley

Lockley, S. W., Skene, D. J., Arendt, J., Tabandeh, H., Bird, A. C., & Defrance, R. (1997). Relationship between melatonin rhythms and visual loss in the blind. *The Journal of clinical endocrinology and metabolism*, *82*(11), 3763–3770. https://doi.org/10.1210/jcem.82.11.4355

Lockley, S. W., Skene, D. J., Butler, L. J., & Arendt, J. (1999). Sleep and activity rhythms are related to circadian phase in the blind. *Sleep*, *22*(5), 616–623. https://doi.org/10.1093/sleep/22.5.616

Lockley, S. W., Skene, D. J., Tabandeh, H., Bird, A. C., Defrance, R., & Arendt, J. (1997). Relationship between napping and melatonin in the blind. *Journal of biological rhythms*, *12*(1), 16–25. https://doi.org/10.1177/074873049701200104

McCall, C., & McCall, W. V. (2012). Comparison of actigraphy with polysomnography and sleep logs in depressed insomniacs. *Journal of sleep research*, *21*(1), 122–127. https://doi.org/10.1111/j.1365-2869.2011.00917.x

Murphy, C., Duponsel, N., Huang, X. S., Wittich, W., Koenekoop, R. K., & Overbury, O. (2015). Retinal Disorders and Sleep Disorders: Are They Genetically Related? Journal of Visual Impairment & Blindness, 109(5), 359–370. https://doi.org/10.1177/0145482X1510900505

Oka, K., & Shibata, A. (2009). Dog Ownership and Health-Related Physical Activity Among Japanese Adults. *Journal of Physical Activity & Health*, *6*(4), 412–418. http://doi.org/10.1123/jpah.6.4.412

Ouzzani, M., Hammady, H., Fedorowicz, Z., & Elmagarmid, A. (2016). Rayyan—a web and mobile app for systematic reviews. *Systematic Reviews, 5*(1), 210. https://doi.org/10.1186/s13643-016-0384-4

Ramos, A.R., Wallace, D.M., Williams, N.J. Spence, D.W.; Pandi-Perumal, S.R.; Zizi, F.; Jean-Louis, G. (2014). Association between visual impairment and sleep duration: analysis of the 2009 National Health Interview Survey (NHIS). *BMC Ophthalmology,* 14(1), 115. https://doi.org/10.1186/1471-2415-14-115

Sack, R. L., Brandes, R. W., Kendall, A. R., & Lewy, A. J. (2000). Entrainment of Free-Running Circadian Rhythms by Melatonin in Blind People. *New England Journal of Medicine*, 343(15), 1070-1077. https://doi:10.1056/nejm200010123431503

Sack, R. L., Lewy, A. J., Blood, M. L., Keith, L. D., & Nakagawa, H. (1992). Circadian rhythm abnormalities in totally blind people: incidence and clinical significance. *The Journal of clinical endocrinology and metabolism*, *75*(1), 127–134. https://doi.org/10.1210/jcem.75.1.1619000

Skene, D. J., & Arendt, J. (2007). Circadian rhythm sleep disorders in the blind and their treatment with melatonin. *Sleep Medicine*, *8*(6), 651-655. https://doi.org/10.1016/j.sleep.2006.11.013

Suni, E. (2020, September 24). *Circadian rhythm.* Sleep Foundation. https://www.sleepfoundation.org/circadian-rhythm

Tamura, N., Sasai-Sakuma, T., Morita, Y., Okawa, M., Inoue, S., Inoue, Y. (2016). A nationwide cross-sectional survey of sleep-related problems in Japanese visually impaired patients: prevalence and association with health-related quality of life. *J Clin Sleep Med*,12(12),1659–1667. https://doi.org/10.5664/jcsm.6354

University of South Australia. (2021, May 14). *PRISMA-ScR.* University of South Australia. https://guides.library.unisa.edu.au/ScopingReviews

Villines, Z. (2017, November 1) *What is the pineal gland?* MedicalNewsToday https://www.medicalnewstoday.com/articles/319882

List of tables and charts

Table 1. displays the length of the research.

Article number (year)	Period of time	Article number (year)	Period of time
A1 (2010)	30 days	A8 (2002)	14 days
A2 (2016)	30 days	A9 (2017)	30 days
A3 (2018)	3 days	A10 (1997)	3-5 weeks
A4 (2017)	30 days	A11 (1999)	3-5 weeks
A5 (2017)	7 days	A12 (1997)	30 days
A6 (1998)	7 days	A13 (2015)	30 days
A7 (2001)	2 years	A14 (1992)	6 weeks

Table 2. shows the frequency of the preferred period of time of a research.

Quantity	Period of time	Quantity	Period of time
1	3 days	2	3-5 weeks
2	1 week	1	6 weeks
1	2 weeks	1	2 years
6	30 days	X	X

Table 3. lists the different methods utilised during the research. Year refers to the year of publication of the article.

Article number (year)	Methods	Article number (year)	Methods
A1 (2010)	PSQI	A8 (2002)	urin melatonin, salivary melatonin , PSQI, sleep logs, actigraph, PSG
A2 (2016)	PSQI, actigraph	A9 (2017)	PSQI
A3 (2018)	PSQI, PSG	A10 (1997)	urin melatonin, PSQI

A4 (2017)	cortisol salivary, melatonin salivary, PSQI	A11 (1999)	urin melatonin, PSQI, sleep logs, actigraph
A5 (2017)	PSQI, actigraph	A12 (1997)	urin melatonin, PSQI, sleep logs
A6 (1998)	PSQI	A13 (2015)	Blood for genetic testing, PSQI
A7 (2001)	PSQI	A14 (1992)	Blood samples for melatonin, cortisol and sleep propensity

Table 4. shows the proportion of the different countries represented in this scoping review.

Article number (year)	Country	Article number (year)	Country
A1 (2010)	Nigeria	A8 (2002)	France
A2 (2016)	Denmark	A9 (2017)	China
A3 (2018)	Denmark	A10 (1997)	United Kingdom
A4 (2017)	Denmark	A11 (1999)	United Kingdom
A5 (2017)	Brazil	A12 (1997)	United Kingdom
A6 (1998)	United Kingdom	A13 (2015)	Canada and Holland
A7 (2001)	Spain	A14 (1992)	U.S.A.

Table 5. Shows part of the PSQI and Articgraph results from table 2 in article number 5.

Group	Describes	PSQI (subjective)	Articgraph(objective)
Blind	Sleep durations (hrs)	5.67	6.48
Low vison	Sleep durations (hrs)	6.39	6.60
Control	Sleep durations (hrs)	6.84	6.80

Blind	Sleep latency (minutes)	50.37	5.47
Low vison	Sleep latency (minutes)	31.44	5.18
Control	Sleep latency (minutes)	19.41	5.16

Table 6. Shows part of the PSG results from table 3 in article number 8.

PSG index	Blind group	Control group
Sleep latency (min)	27.33	12.16
Sleep efficiency (%)	76.2	92.3
Total sleep time (min)	289.7	424
REM (%)	12	23.7

Table 7. PSQI score results of the blind participants from article number 8.

PSQI category	Blind participants nr.	Percent
mild sleep disturbance	6	23%
moderate sleep disturbance	9	34.6%
severe sleep disturbance	11	42.4%

Table 8. Shows LP and NLP subjects circadian rhythm types taken from Table 3. in article number 10.

LP type	Normal	Abnormal	Free	Unclassified	Total
LP sum	**14 (74%)**	**4 (21%)**	**0**	**1 (5%)**	**19 (100%)**
NLP - 2 eye	4 (33%)	5 (42%)	2 (17%)	1 (8%)	12 (40%)
NLP - 1 eye	2 (29%)	0	5 (71%)	0	7 (23%)
NLP - 0 eye	1 (9%)	0	10 (91%)	0	11 (36%)
NLP subtotal	**7 (23%)**	**5 (17%)**	**17 (57%)**	**1 (3%)**	**30 (100%)**
LP+NLP total	21	9	17	2	49 (100%)

Table 9. Shows the aMT6s rhythm variations among the participants with different pathology.

Pathology (P.)	Normal	Abnormal	Free	Total of P. groups
NLP - 2 eye	1 (20%)	3 (60%)	1 (20%)	5 (100%)
NLP - 1 eye	2 (40%)		3 (40%)	5 (100%)
NLP - 0 eye			5 (100%)	5 (100%)
Total of rhythms	3 (20%)	3 (20%)	9 (60%)	15 (100%)

Table 10. Lists the PSQI sleep component aspects of the results and their frequency in the articles.

Article	Sleep duration	Sleep quality	Sleep efficiency	Daytime dysfunction	Sleep latency	Sleep disturbance	PSQI over 5	PSQI over 12
1							81.2%	49.4%
2							63%	27%
3	X							
7	X	X	X	X	X			
8	X		X		X		100%	42.4%
9	X		X		X		26.7%	
10							X	
11	X				X			
12	X	X		X				
13		X			X	X	64%	

Table 11. Lists the circadian rhythm aspects of the results and their frequency in the articles.

Article	Out of phase	NE LP	AE LP	FR LP	NE NLP	AE NLP	FR NLP

1							
2							
3	X						
4	X						
5							
6	X						
7	X						
8	X						
10		74%	21%		23%	17%	57%
11		X	X	X	X	X	X
12					20%	20%	60%
14					15%	15%	55%

Table 12. Lists different aspects of the results and their frequency in the articles.

Article	LP/NLP considered	Napping	No difference pathology	Sleep & sport	Gender irrelevant	Age irrelevant
1	YES	65.9%			YES	YES
2			YES			
3			YES			
6		10%		YES		
7					YES	
8		YES	YES			
9				YES		
10	YES				YES	
11	YES	YES				
12	YES					YES
13						YES
14	YES					